A Final Report for

Infrastructure to support massively parallel computing with adaptive unstructured grids

Submitted by

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This contract provided $143,500 from the AFOSR combined with $61,500 of cost sharing directly from Rensselaer Polytechnic Institute for the procurement of computer hardware to facilitate AFOSR sponsored research under the fol-lowing research: i) Large Eddy Simulation (LES) of turbulent flow over an airfoil using unstructured grids (Grant # F49620-97-1-0043) and ii) Crystal growth simulations and iii) parallel adaptive computations. To further leverage these funds they were combined with an additional $208,000 from a National Science Foundation research infrastructure grant (plus an additional $40,000 in Rensselaer matching for that grant) and an additional $138,000 from Silicon Graphics Inc. to purchase the following very substantial computational facility from Silicon Graphics Inc.:
 1. 8 R10000 processors, 2. 3.5 Gigabytes shared memory (addressable by all processors), 3. 18 Gigabytes fast access hard disk, 4. Onyx2 InfiniteReality graphics engine, 5. 24 inch super-wide monitor, 6. Fakespace virtual reality stereoscopic visualization system (6' by 8' table with a 6' by 4.5' visualization surface that can be tilted to any angle), 7. Indigo2 workstation with 1 R10000 processor, 8. 320 Megabytes memory, 9. 9 Gigabytes hard disk, 10. SolidImpact Graphics engine, 11. 20 inch Multi-Scan monitor,

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1 Summary

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8. 320 Megabytes memory,

9. 9 Gigabytes hard disk,

10. SolidImpact Graphics engine,

11. 20 inch Multi-Scan monitor,

This facility has a list price of nearly $920,000 but due to the educational discount and the additional leveraging funds, only $143,500 of AFOSR funds were required (a factor of 6.4 in leverage).

This machine has immediately made an impact on our research in two important ways. First, since it does have 8 processors it has provided an excellent environment for the development of our parallel algorithms. By debugging and tuning our algorithms on this machine, not only do we enjoy faster development of code but we also are able to use the large DOD computers for production runs only.

The second impact that this machine has had on our research is for pre- and post-processing. We often deal with very large meshes with 10's of millions

of degrees of freedom. The 3.5 Gigabytes of shared memory has allowed us to generate and visualize much larger meshes than were possible before. This has lead to higher quality meshes which in turn lead to high quality simulations. Equally important is the new ability this machine has given us to visualize these solutions. The printed medium of this report does not allow us to display the true impact that this machine has had on our research. The interested reader should look at the following URL (http://www.scorec.rpi.edu/ kjansen) to observe several animations of turbulent flow that were made possible by this computer. One frame of the airfoil simulation is included with this report. Videotapes of these animations have also been provided to Dr. Leonidas Sakell, the program manager of the LES research. The facility has also enabled visualization research by attracting new researchers in this area (Will Schroeder, author of VTK (Visualization Tool Kit, a budding standard in graphics visualization that was used extensively in the animations mentioned above)).

In summary, the AFOSR's support of the procurement of this equipment has had a major impact on AFOSR sponsored research at Rensselaer Polytechnic Institute by enabling the above listed faculty, their 6 postdoctoral fellows/research staff, and 10 students unfettered access to a state of the art computational/graphics facility.
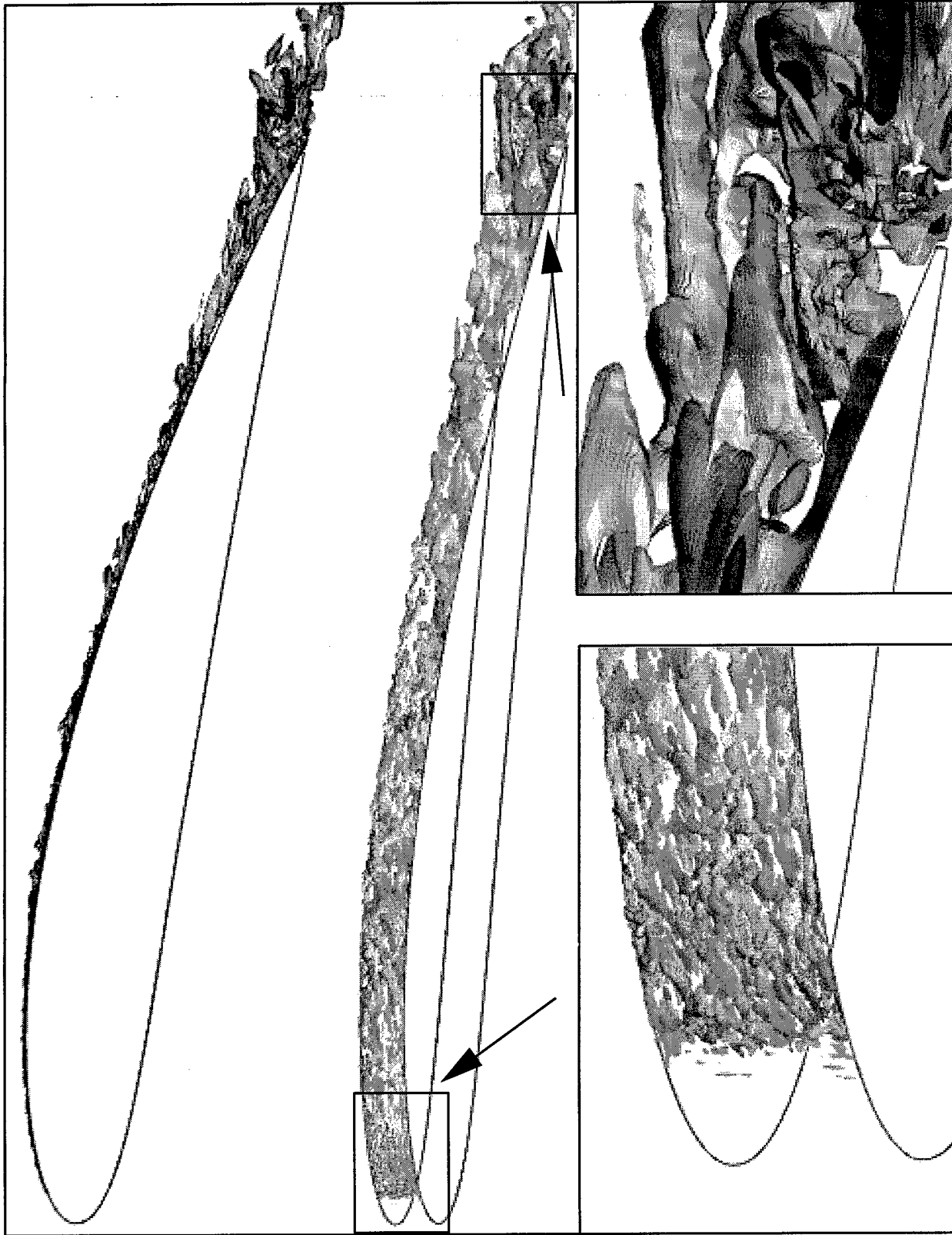
Figure 1: Tip-to-tail development of the turbulent structures identified by spanwise velocity isosurfaces in the boundary layer over the upper surface of the airfoil. Top figure provides a side view which illustrates the development of the boundary layer thickness. The middle figure tilts slightly to show the spanwise structures. Lower left figure zooms in on the early boundary layer while the lower right zooms on the tail region illustrating the dramatic variation in spatial scales.